P19  Optical Configurations of TW-IPS LC cell for very wide viewing angle in large size TV application

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1. Introduction

S-IPS (Super In-Plane Switching) LC cell exhibits excellent viewing angle characteristics intrinsically, so that it can be applied for large size TV applications. If the performance parameters which describe the actual visual performance are considered, S-IPS mode is much more advantageous [1]. In spite of the merit mentioned, it shows relatively low contrast ratio in diagonal direction compared to viewing angle characteristic in upper and down direction in S-IPS because the effective angle between the absorption axes of a polarizer and a analyzer in the diagonal direction increases in proportional to observing direction [2-4]. In order to improve the viewing angle characteristics of S-IPS in diagonal direction, several types of optical configuration of S-IPS have been proposed. Chen has shown a combination of a positive A plate with a positive C plate [5]. And Saitoh also has shown a configuration using one biaxial film (NEZ film) [6].

In this paper, we propose TW-IPS cells (True Wide IPS) which is novel optical configurations to improve viewing angle characteristics in diagonal direction. The TW-IPS cell is an optically improved S-IPS LCD which exhibits excellent viewing characteristics by applying optimized compensation films. The TW-IPS is composed of one or two compensation films. We calculate the optical characteristics of the proposed TW IPS cell and compared the result with experimental results in order to verify.

2. Optical configuration of the TW IPS cell for wide viewing angle

In order to find the optimized device configurations, we need to consider the configuration of the S-IPS cell. Fig. 1 shows the typical structure of the S-IPS cell. It does not contain any retardation films except TAC films attached on the polarizer as shown in Fig. 1. It has negative C plate characteristics ($\Delta n \approx 50$ nm).

![Diagram of S-IPS cell configuration](image1)

Fig 1. Typical optical configuration of the super IPS cell

![Polarization of the light passing through the IPS cell on the Poincare sphere](image2)

Fig 2. Polarization of the light passing through the IPS cell on the Poincare sphere

In order to exhibit high contrast characteristics, entrance and exit polarizer are crossed with each other and the optical axis of the LC director is parallel to the absorption axis of the polarizer. In diagonal direction, the light passing through the LC
cell will feel the effective absorption axis to be changed, so that the contrast ratio may decrease because of dark state especially. Figure 2 shows the polarization state of the light obliquely passing through the cell in the diagonal direction on the poin’care sphere. Oblique incident light in diagonal direction could experience deviated polarization angle compared with normal incident light, so that effectively angle of the polarizer will deviate with 0 from S1 (position A) which is a polarization state of the polarizer in normal direction (0°). Therefore, the oblique incident light starts at point A. E and F represent effective polarization positions of the angle of the analyzer and the optical axis of TAC films with oblique incident light, respectively. ∅ in Fig. 2 represents the position of polarization of the light. The polarization of the light passing through the bottom TAC film will go to the position B from A through path L1. Next, passing the half-wave IPS cell makes the position of the polarization C with path L2 and finally, it goes to position D by passing through the top TAC film again. As shown in Fig. 2, polarization of the light in front of the analyzer is a little bit apart from the position of the opposite position of the analyzer, so that we can understand the light leakage in the dark state.

Fig 4. Polarization of the light passing through the TW IPS cell on the Poin’care sphere

Blocking of the light leakage in the dark state in diagonal direction can be achieved by using the optical configurations in Fig 3. (a) and (b). An optical configuration of the Fig. 3 (a) consists of a A plate and a biaxial film (type 1). Otherwise, we can also obtain improvement by using a combination of A plate and A, positive C plates as shown in Fig 3 (b) (type 2). Figure 4 shows the principle of the TW-IPS cell. Optical axis of A plate is parallel with polarization angle of the polarizer. The light passing through A plate and the IPS cell moves to position D and it approach to the position G by the biaxial film. Used biaxial film is NEZ film of Nitto Denko (Nz=0.5). In this case, the optical axis of the biaxial film keeps the position at S1 even if the oblique angle is changed because of the Nz value. Finally, we can make the polarization of the light in front of the analyzer almost perpendicular to the angle of the analyzer by passing through the top TAC film (position H).

In order to verify the calculated result, we measured optical performances of the S-IPS cell and the TW-IPS cell. Figure 5 the measured optical contrast of the S-IPS cell and the TW-IPS cell. We applied type 1 of the proposed configurations because type 2 also showed very similar optical characteristics to type 1. From the figure, we can find improved viewing angle characteristics compared with the S-IPS cell. Especially, optical contrast in diagonal direction of the TW IPS cell has much more improved compared with S-IPS cell.
3. Conclusion
In conclusion, we proposed two optical configurations of TW-IPS LC cell by applying optimized compensation films to S-IPS cell. We found much more improved viewing angle characteristics compared with the S-IPS cell. We applied the novel optical configurations to our 32-inch TFT-LCD for TV application.

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